Case Summary 1- Implementing Lean Six Sigma: A Case Study in concrete panel production.

This paper describes the attempted implementation of lean six sigma methodology in construction industry. Prior to this, Lean six sigma has been mainly used in manufacturing industry. The adoption of this method is to improve the process by eliminating variables and creating workflow in the process. They hypothesised that six sigma technique can be applied to the construction based production system along with lean construction techniques.

Lean six sigma methods were applied to concrete panel production system in a multi housing complex project. This leads to improved production rate and stabilization process. The main **Critical total Quality** was the reliability of panel production rate of each day because the process depends mainly on production rate.

Background

The Phase II of Jubail Industrial City in Saudi Arabia is undergoing development. 405 villas need to be developed in one part of phase II. Precast wall and floor panels were chosen for construction due to speed and efficiency in production and installation.

Define: A Black Belt six sigma team (Bechtel's Six sigma team) was introduced in order to avoid additional delays in the project and housing shortage. Their role was to solve the following problems ie **problem statements,**

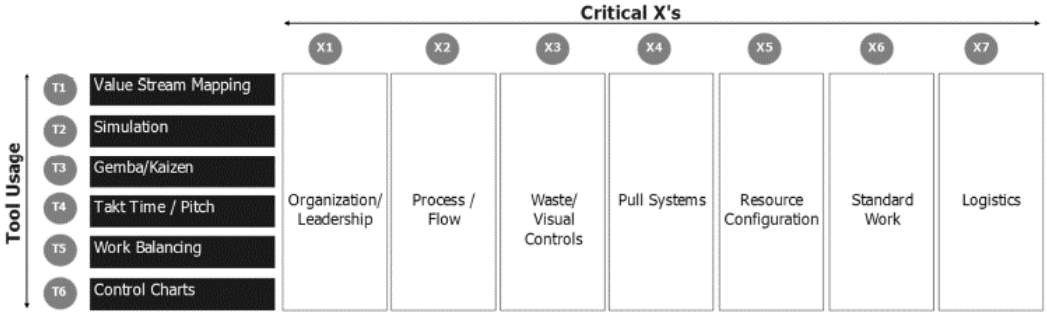
1. Improve productivity of fabricating and delivering precast insulated panels to construction site.
2. Establish causes of delays, address inefficiencies at precast plant and propose remedial measures
3. Operate at takt time interval
4. Achieve all critical milestones per contract terms and conditions

Measure: Primary metric for measuring output Y was determined as ''the number of exterior insulated panels delivered to construction site per day''

Current production rate= 18panels/day

Target production rate to achieve goal = 75panels/day

Analyse: In order to illustrate the common and special sources of variation, the critical X's were represented in a **Values Stream Map**



VSM showing the critical X's

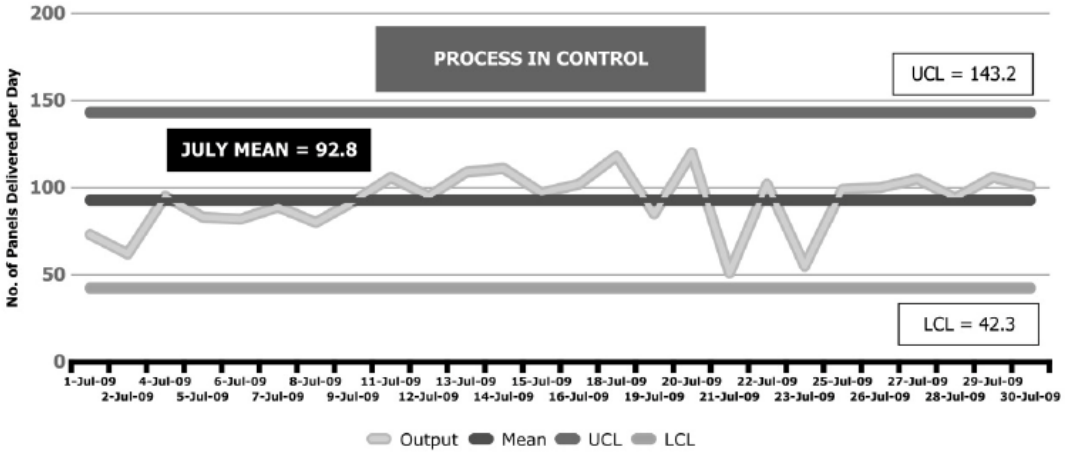
Note that the output,Y may also be variable due to variations in the input

Y = Daily production rate

Improve: Some actions taken to take care of critical X's and improve production include(a few are stated here)

1. Improve leadership/supervision including dedicated plant manager, appoint 4 foremen each to 6 productions, hire a quality project engineer.
2. Optimize process flow by increasing resource utilization like adding night shift.
3. Eliminate waste through improved inventory management including reduction of inventory level to maximum of 250, use visual control to display product status, better workplace flow.
4. Document standard work and improve logistics including measuring cycle time and decrease lead time.

Control: By identifying and tackling the critical X's, the production rate of 75panels/day was achieved. Performance improvement was measured using control charts which gave a Cp of 0.9 meaning the process is under control



Sustained Performance – Control Chart

Summary

Observation of this case study showed how lean tools were used to optimize work process and improve speed and efficiency. Six sigma tools were also used to identify and eliminate critical X's. It should be noted that using each tool alone would not have been able to achieve set goals but integration of lean and six sigma was able to improve and solve the construction problems including reducing variability and daily production rate.

CASE 2 SUMMARY

PAPER ORGANIZERS INTERNATIONAL: A FICTITIOUS SIX SIGMA GREEN BELT CASE STUDY

Paper Organizers international (POI) is a company that offers a full range of filling, organizing and paper shuffling services. They do this with the aid of metallic securing devices(MSD). POI has noticed an increase in complaints from employees in the paper shuffling department (PSD) about MSDs breaking and failing, causing papers to mix together. In order to improve the process of purchasing MSDs to eliminate complaints, Six sigma methodology was introduced.

Background: Current Performance levels

Monthly production cost in PSD were analyzed using **IM-R charts** which showed stable production costs(no special causes of variation). Average monthly cost was $1,096,880 and standard deviation of $99,000 . Team estimates PSD mothly production cost to be too high given the volume of work being processed.

A **cause and effect type matrix** is used to prioritize four(4) potential six sigma projects ie each s weighed against business objectives. The most critical project with respect to business objectives is MSD Quality project. An initial **project charter** is prepared and presented to the members of the MSD quality team.

Define Phase: This phase contained 3 components; **project objective, SIPOC analysis and VOC analysis.**

a. **Project objective:** The team prepared the project objective by asking team members to answer certain questions. Some are; i.)what is the name of the process ii.)what is the aim of the process iii.)why do the project at all. iv.)why do the MSD project now. V.)what are the consequences of not doing the project. Vi.) which projects have higher or equal priority. Vii.)what is the problem statement. Viii.)what is the goal.
   These questions enabled the team leader and champion to draw out the project goals, scope, boundaries, team membes roles and responsibiities, expectations, cost and duration.
b. **SIPOC Analysis:** was done to identify the suppliers and thier inputs to the process; the process itself, the outputs and the customers interested in the output.
c. **Voice of customer Analysis:** VOC data was collected from customers(verbal and written) from a sample of users in a selected market. Data was then analyzed and converted into critical to quality variables namely, duration, color and functionality. **Kano Questionnaire** was used to classify a set of CTQs into appropriate quality categories.

Project Objective 1: Decrease (direction) the percentage of MSDs that cannot withstand four or more bends without breaking (measure) bought by the Purchasing Department (process) to 0.62% (goal) by January 1, 2004 (deadline). Go for Four Sigma!
Project Objective 2: Decrease (direction) the percentage of boxes of MSDs with more than five broken clips (measure) bought by the Purchasing Department (process) to 0.62% (goal) by January 1, 2004 (deadline). Go for Four Sigma!

Measure: 3 steps were used in this phase

a. Operationally define each CTQ: Team defined durability and functionality by developing a test for each criteria and formulating a decision rule for each criteria.

b. Perform a Gage R and R study on each CTQ: **Attribute Gage R&R** was conducted on the measurement system of each CTQ to determine its adequacy for project needs. Minitab Gage **Run chart** showed theres no variation between and within inspectors. Thus measurement system is acceptable for both functionality and durability.
c. Develop a baseline for each CTQ: Statistical analysis were carried out to determine baseline capability for each CTQ. This was done using **IM-R charts, Dot plot, c-chart** for durability(attribute non normal data). Sample selection plan was constant through out the process.

Analyze: Involved 5 steps

a. A more detailed process map was developed identifyng and linking the Xs and Ys
b. Operational definitions for each input X or process variable is constructed
c. Gage R&R was performed on each X to determine the adequacy of the measurement system for X
d. Baseline for each X is developed
e. Hypothesis between Xs and Ys were developed.

Improve: Experiments were designed to describe the relationship between the Ys and the vital Xs and the major noise variables. Actions needed to implement the vital few Xs, optimize the shape,spread and center of the distribution of Ys are developed. Also, pilot tests were developed and conducted to test action plans. An experimental design was conducted to determine the effect of X1(vendor) X2(size and X3(ridges) on the Ys with X7=0. A 2^3 full factorial design with 2 replications was performed for durability and functionalty (**DOE**). The experiment was set up in 2 blocks to increase experiment reliability. **Pareto charts** were also used to assess the effects of Xs for durability and functionality. The major effects at 90%CI for durability are vendor interacion, size and main efffect due to ridges. There were no significant effect due to vendor,size of ridges for functionality. Functionality can be improved by addressing shelf life first, because durability was shown to be affected by the Xs, more consideration was restricted to durability.

Interaction effect plot between size and vendor shows that the best result for durability were obtained using small MSDs supplied by office optimim or large MSDs supplied by Ibrix. Team also decided to take on another project to decrease shelf life to less than 5 days to address functionality. Thus flow chart was revised.

Control: involved actions to mistake proof the improvements discovered in the six sigma project. Also involved creating a risk management plan to minimize failure risk of product or service and preparing a control plan for the process owners. The team identified and prioritized two problems while mistake proofing.

a. Purchase agents don't specify "with ridges" on purchase order b.) purchasing agents don't consider that the vendor choice depends on size of MSDs requested.
   Solutions were then created. They are
   1.) ensure that "with ridges" is specified on purchase order before processing. 2.) Office optimim is selected for small MSDs and Ibrix for large MSDs must be specified on order.

Team members also identified risk elements using risk management and assigned risk ratings. Risks were dealt with using **risk abatement plans.** The risks included a.) failing to train new staff in new purchasing process. B.)office optimum and Ibrix are out of MSDs with ridges. ISO9000 documentation were prepared for the revisions to training manual for purchasing process. A control plan that requires monthly sampling of the boxes of MSD inventory was developed to check whether the right size and vendor purchases were made.

CASE SUMMARY 3
Application of Six-Sigma in finance: a case study

Background

The following presents a case study on the usage of six sigma methodology within a finance department. The goal was to streamline and standardize the establishment and maintenance of cost and planning for all business activities within the current financial management process. It is a continuing account reconciliation enhancement project.

Six sigma at IDS

For discretion purposes, the firm name is termed IDS. A company wide six sigma implementation was used in this study. It was developed by benchmarking the best practices of two other defense contractors and also Toyota's lean thinking model. The project received company wide support. The team comprised of a Master Black Belt holder and a team of Black Belters.

Primary goal was to develop overall six sigma strategy consistent with customer requirements and company mission statement. **Long term goal** was to create special level project opportunities for the division that could lead to cultural change in te workplace.

40 projects were identified and prioritized and The Continuing Account Reconciliation Enhancemnt program (CARE) was chosen and discussed below using DMAIC.

Define: Team visualized opportunity to develop a standardized process for establishing and maintaining cost and financial planing for all business divisions within current financial system in collaboration with primary stakeholders, it involved identifying the Non value aded activities within the current process, implementing improvements in control system to get sustainability and results that will change the way people think.

Team worked with nternal customer to define the objectives of project including opportunity statement, scope, schedule, budget and constraints.

Problem statement: ''the process can't produce all financial planning and analysis requirements in the most efficient manner''. Primary objective was thus to streamline and document all cost elements in the planning process for the current system two issues sneeded to be addressed

1.)Clarify the current financial reporting process for internal customer

2.)Envision an improved process for both internal (firm contracts) and external (non firm) customers who outsource thier financial reporting to IDS.

Measure: Team conducted **Value Stream Mapping Analysis** to measure performance of current process in terms of aveage hours required to complete reports and total cost of preparing reports using **Activity Based Costng.** This showed poor financial planning process causing loops which caused the NVAA e.g errors, excess movement, extra training and maintenamce cost e.t.c. The reporting process was revised to incorporate management change requirements and the database was updated as needed using BPS(Business planning and simulation) software. The team found that the finance department spent a total of 200hours to generate 20 reports at an average cost of $360,000.

Analysze: Team created **cause and effect diagram** to identify the possible root causes

Causes identified included;

1.)Lack of complete firm cost and financial plans.

2.)Multiple sources of data and databases.

3.)Lack of complete non-firm cost and financial plans.

Team then carried out further detailed analysis to identify contributing factors for each major cause.

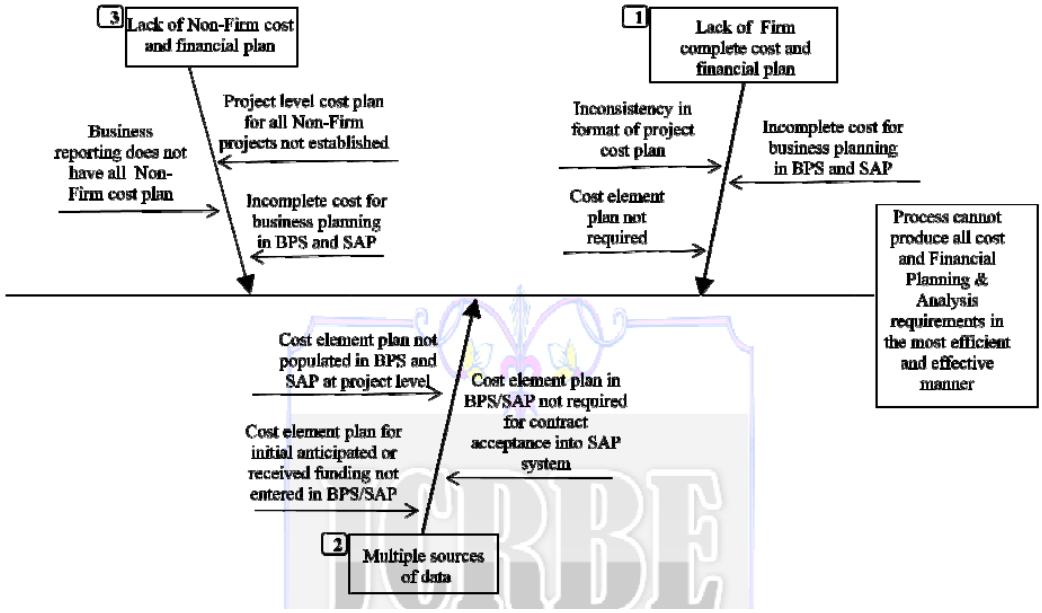
Value Stream analysis was then used to recommend the following actions for overall process performance improvement.

1.)Identify all business divisions that require a baseline in curent financial database.

2.)Establish baseline data by resource, cost element and time phasing for each project.

3.)Identify and eliminate all NVAA to improve response time at all levels of management.

Cause and Effect Diagram


3
Lack of Non-Firm cost and financial plan
Business reporting does not have all Non-Firm cost plan
Project level cost plan for all Non-Firm projects not established
Incomplete cost for business planning in BPS and SAP
1
Lack of Firm complete cost and financial plan
Inconsistency in format of project cost plan
Cost element plan not required
Incomplete cost for business planning in BPS and SAP
Process cannot produce all cost and Financial Planning & Analysis requirements in the most efficient and effective manner
Cost element plan not populated in BPS and SAP at project level
Cost element plan for initial anticipated or received funding not entered in BPS/SAP
Cost element plan in BPS/SAP not required for contract acceptance into SAP system
2
Multiple sources of data

Improve: Team provided two solutions for implementation by finance department.
1.)Implement all actions proposed via VSM analysis.
2.)Redesign process by creating new process chart which simplified the process by removing the NVAA.
Further team recommendations to enhance financial reporting includes
1. Develop initial cost-element plans by project for both internal and external contracts.
2. Regularly copy cost plans to various FP&A versions for five-year planning, sales forecasting, and bookings forecasting.
3. Update and maintain cost-element plans as new businesses are identified and funding is received.
4. Update and maintain financial plans.
5. Copy updated financial plans to various FP&A versions accordingly.
After implementation, the following results were achieved
•Cost-element and financial planning activities for all business divisions were standardized, consistently created and maintained in a centralized database;
• Processes were streamlined, documented, and consistently followed throughout the reporting process;
• Significant reduction in cycle time was achieved for producing the FP&A reports;
A cost savings of $130,000 was recovered. This is cost avoidance.
Control: To sustain results gotten, the team standardized, documented and distributed the new process for the finance department to follow. Ongoing performance was monitored and was part of formal performance evaluation process.
Lessons learned from this case study are as follows:
1. Lack of standardize, clearly documented, and agreed upon processes inevitability leads to variability which results in confusion and adds labor cost.
2. Maintaining a single centralized database (verse multiple databases) can reduce systems maintenance costs, data duplication, and overall processing cycle times.
3. Six Sigma Methodology can be successfully applied in business functions and services other than manufacturing operations.

CASE SUMMARY 4

Applying lean Six Sigma to reduce linen loss in an acute care hospital

BACKGROUND

This case study describes the application of six sigma problem solving methodology in an acute care hospital to improve linen process. A cross functional team was formed with a goal to identify and implement process improvements that would decrease linen loss. Application of DMAIC led to improvement of key linen operational metric, soil to clean ratio by 16% and saved $77,480 for the first year.

Lean six sigma methodology application.

Define: After identifying the problem of linen loss, the Hospital supply chain committee reviewed supply expense and identifies where theres potential opportunity for reducing these expenses. Steps executed in the define phase includes

a. Develop Project Charter: Team developed the project charter which scopes the project and define the processes to be improved. It also identifies customers and stakeholders of the project as well as project goals. Furthermore, the project statement as well as projected financial benefits were outlined.
b. Stateholder analysis: The primary stakeholders, who they are and thier potential impacts/concerns was outlined here. The Primary stakeholders includes inpatient nursing, supply chain/material management, emergency department, security etc.
c. Perform initial Voice of customer and identify Critical to satisfaction (CTS): VOC was conducted. The CTS criteria for the project are;

i. Efficient distribution of linen. Ii.) appropriate use of linen iii.) avalability of linen iv.) secuity of linen v.) Linen loss.

d. Select teams and launch the project: Team consisted of cross functional stakeholders group, MBB mentor. team members included: Materials, Management/Linen, Nursing, Environmental Services, Wellness Center, Security, Surgical Services, Emergency Department, Imaging, Enterprise Performance Excellence Center.
e. Created project plan: project milestones fo each stage of DMAIC was set.

Measure: Current process was mapped and measured to determine baseline metrics and to validate measurement systems. The following activities were carried out.

1.) Define the current process: Detailed process maps of linen distribution were created. It showed a daily average loss of 10 pairs of scrubs which could sum up to $140,000 per year. A data collection plan was developed to measure the critical to satisfaction criteria and also identify metrics, analysis mechanisms, sample plans and baseline measures.

A soil to clean ratio was developed to assess the linen loss in the hospital.

2.)Define detailed VOC

3.)Define Voive of Process(VOP) and current performance: Current and expected performance levels were assessed.

4.)Validate measurement systems: The soil to clean ratio system developed to assess linen loss was assessed and validated.

Analyze: Team identified process problems and thier root causes. Activities carried out includes

1.) Develop cause and effect relationships. Potential root causes for linen loss was **brainstormed** and several **why-why** diagrams were created(**5 whys**). Some of the root causes were Linen Not Secure, Measurement issues, Linen/Scrubs “walking out” of the hospital, Linen Return, Retained Linen.

2.)After validating the root causes, it wwa discovered that the process were not capable of securing the linen.

Improve: Team identified and piloted linen improvements. Steps includes

a.)Idenify improvement opportunities and plans: Team created improvement ideas aligned with root causes. They include; better linen security, weighing of linen(better measurement system), proper scrub management within hospital, no more linen walking out of the hospital, training on proper linen placement.

b.)Cost benefit Analysis: was performed by the master black belt. **Net Present Value** was estimated to be $625,539 for a 5year project life. Internal Rate of Return was 148%. Total annual savings of $238,815. Initial cost was $10,000. The positive NPV and IRR convinced the leadership team that the project was a good investment.

c.)Design future state: Team revised process maps to represent new processes

d.)Establish performance targets and project scorecard.

e.)Pilot improvements

f.) Train and execute

Control: Team carried out the following procedures to maintain the level of improvements attained.

a.)Measure result and manage change: MBB performed a **2 proportion test** comparing the baseline to the first quarter result(after project implementation). No significant difference was found, meaning theres a statistical significant improvement and reduction in linen replacement cost of $1490 per week, $77480 annually.

b.) report scorecard data and create process control plan: control means for monitoring metrics and actions to be taken if situations change were sorted out.

c.)identify replication opportunities

d.) Develop future plans

Summary

The Lean six sigma application resulted in sucessful linen loss reduction, savings of $77,480 in the first year and reduction of soil to clean ration by 16%

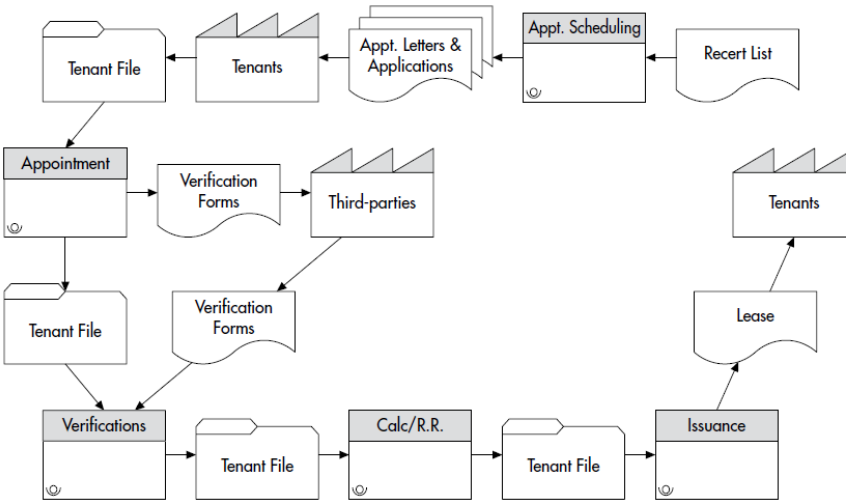
CASE SUMMARY 5
Exploring the Use of Lean Thinking and Six Sigma in Public Housing Authorities

BACKGROUND

The every growing need for public housing has made authorities to find innovative ways of doing more with less. This case study explores whether the use of lean thinking and six sigma can be succesffully applied to public housing. It demonstrates how lean and six sigma was applied to a public housing authority project performed by Dakota county community development agency.

Define: A cross functional team was formed with members from different departments. Thier first task was to agree on what the project is and what it should accomplish. The primary goal was to reduce the amount of waste or non vaue added activities in the senior housing reexamination process. The reexamination process is a process of reexamining the rent of tenant based on thier yearly income. This process was seen through by the principal stakeholders(senior housing tenants and local government).

Process improvement could be measured in terms of percentage reduction in staff time required for the process. Information about the reexamination was gathered via a current state **value stream map**. This allowed the team to view the current process and understand it so as to pinpoint the NVAA. From the VSM, it was discovered that only 1hour and 41mins of actual VAA was indicated whereas the entire reexamination process had a cycle time of up to 90days(unlean process). The remaining time comprised of NVAA like wait time, rework and queue time.

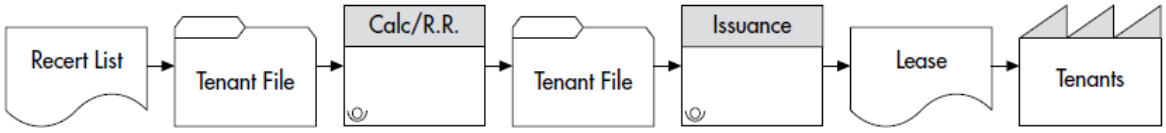


Current state value stream map

Measure: Team collected data to measure the current performance levels of the reexam process. Data was collected via VSM as well as data related to the income based rents calculated by the reexamination process. Data analysis was limited to determining a per unit monthly rental amount (PUM) calculated as the amount of rental income divided by the number of unit months in the period.

Analysis of income based rents via **histogram** indicates a significant amount of variation with a mean monthly rent of approximatel $538 and a standard deviation of $134. Furthermore, some tenants were also receiving government rent subsidies in addition to paying thier income based rents. This showed insight into the causes of variation in the senior housing project.

Analyze: Team set out to identify the root causes of waste and poor quality. From the data previously collected, the team sought to analyze the results of the reexamination process. It observed that the rent changes from the process was quite small with only a few significant changes. Team also observed that from the underlying rent calculations, the tenants had little changes in income. Thus a great deal of time and money was being spent on activities that provided little or no value to the stakeholders. The few rent changes noted were due to irregular occurring events e.g asset disposition, changes in household composition e.g marriage or loss of spouse, employment status change e.t.c.
The current VSM was then analyzed to identify wastes. Most of the wastes could only be eliminated by eliminating the requirement to perform the income and asset verification.
Improve: Team seeks to find best solution and make changes in process to eliminate cost and wastes. The majority of wastes identified were related to the large amount of work required to recertify the income and assets of tenants which resulted in minute changes in the rent. Team resolved to eliminate this requirement. Initial rent would continue to be income based at the time of admission, future rent changes would be based on inflation factors relative to the local market. Also rent changes would be reanalyze in cases of special circumstances stated in he analyze phase.
A future state VSM was developed showing these changes and solutions. It is expected that this proposed VSM would reduce cycle time from 90 to just over 30days, projected 80% decrease in labor required for reexamination process from 1hr41mins to just over 20mins.



Future state VSM
Control: Team seek to consolidate on gains made and make sure it lasts. It involved documenting the new procedures, training staff in the changes and handing off the ongoing management to the new process owner.
It should be noted that there still lies considerable sources of variation in the project(especially regarding financial viability). This may be due to the income based methodology. To reduce this variation, project could adopt a fixed rent. However, being a public program, this will not accomplish the objective of control rather than reduce the variation.

CASE 6 SUMMARY
Six Sigma at Wipro Technologies: Thrust on Quality

This case study focuses on the work of Wipro Technologies to implementsix sigma quaity tool in order to achieve sustained strategic business results. It also touches the recent developments in six sigma concept like Wipro's six sigma skill base and consulting experience.

Background

A leading communication network in the US required improvement in production performance of a telecom application using six sigma methodologies. As a global IT service provider with knowledge of the importance of aligning business operations with customer needs and continuous improvement, Wipro began focusing on quality, thus creating an environment that led to implementation of six sigma. They also intended to bring vigor and effective upstream processes of the software department. Six sigma implementation brought about cost savings, performance improvements and quantitative understanding towards product quality.

Some of the key challenges were

1.)Reduce the data transfer time. 2.)Reduce the risk. 3.) avoid interruption due to LAN/WAN downtime. 4.) parallel availability of the switch for other administrative tasks.

Evolution of Six sigma at Wipro

- First indian company to adopt six sigma
- One of the most mature six sigma programs today. 91% program completion rate. Industry average of 55%
- over 1000 projects rolled out involvng project management, market development and resource utilization.

Difficulties encountered includes

1.)Building the culture: Wipro had to build/restructure its organization to provide infrastructure, training and confidence in the process in order to get required support from higher level managers for six sigma.

2.)Project selection: During the first year of deployment, pilot projects were selected on the basis of high probability of success and target to complete in the shortest possible time. This was a learning phase. Field data and process maps were developed and importance of project was judged from the view of the customer before project was selected.

3.)Training: The first step of implementation was to build a team of professionals and train them in six sigma methodology ie(define,measure,analyze and control) and also increasing customer satisfaction. It involves statistics, benchmarking and design of experiments.

4.)Resources: Resources required for both short and long term basis was shared on basis of seriousness and importance of project.

Project review team was set up to see to timeliness, find out gaps, weak areas and check outcome of project as per the plan.

Implementation of six sigma

1.) For developing new processes

a. DSSS methodology was employed for software development. Its used in process metrics and cause analysis during software development cycle for defect free deliveries and lower cost.

b. DSSP methodology was used for designing new processes and products.

c. DCAM methodology was used for designing customer saisfaction and manufacturability.

2.) For improving existing processes

a. TQSS methodology was used for defect reduction in transactional processes
b. DMAIC methodology was used for process improvement in non transactional processes
3.) For reengineering
CFPM methodology was used for cross functional process mapping
Six sigma team at Wipro consisted of Executive management, champions/development leaders, financial executives, black belts, green belts and yellow belts.
Projects are driven by champions, lead by BB and assisted by GB. The different tools are followed by Wipro for implementation of six sigma include ideation, definition, selection, tracking and reporting. Wipro has 15000+ trainees in six sigma and 180+ black belters. It also offers consulting services in six sigma institutionalization, problem solving and six sigma training.

Benefits

- high financial gains
- 250% achievement process, 6min per MB transfer and 18min for average data transfer. Target was 200%
- lower maintenamce cost, schedule overun cost and development cost.
- improved performance due to understaning of customer requirements.
- improved effectiveness in upstream processes of software development. Life cycle and cycle time reduction
- waste elimination and increased roductivity up to 35%
- cost failure avoidance from 4.5 – 1%
- tangible cost savings

Future focus and challenges

1. Merge six sigma with other tools e.g stretch goals, lean e.t.c
2. Benchmark itself against competitors
3. transform six sigma from a tool for improving production qualit to an overall busness improvement methodology
4. 100% management training in six sigma
5. Make quality number 1 objective for all employees.

CASE SUMMARY 7

Lean Six Sigma in the public sector

APPLYING SIX SIGMA TO IMPROVE QUALITY, REMOVE WASTE AND UNCOVER HIDDEN OPPORTUNITIES IN STATE AND LOCAL GOVERNMENT

Background

In an era where the public demands for greater service at lower cost, organizations cannot afford to be wasteful. The following case demonstrates how lean six sigma can be integrated and utilized to imrove the ways state and local government manage documents and information they have. Governments look for structural systems that reduce waste and achieve more with less.

Lean six sigma applied by Xerox Global

State and local governments seek to improve efficieny by using digital imaging and repository solutions to simplify business processes. Xerox for 17 years has applied six sigma methods to help improve ways of information flow in and out of government agencies using DMAIC.

Define:

Team determines current stae, problem statement and desried future state using project charter. Primary problem statement relates to document management and access. As program progresses, more information are collected and problem statement is refined.

Some of the problems are

- It is difficult for government workers to access or share information that resides only on paper.
- Paper documents are easily misfiled or misplaced.
- Paper-based work processes are slow, expensive, and cumbersome.
- Compliance with the Freedom of Information Act is difficult.
- Providing additional revenue opportunities for electronic access to key documents, such as land records, accident reports, and court notes is challenging.

Measure:

Xerox gathers quantitative and qualitative data to measure current state. Baseline is established in order to evaluate potential solutions via interviews with process owners, process mapping of key business processes and gathering of data. Some measures collected were Amount of storage space being used and how much is available, Number of mail, phone, and fax requests, Number of steps in a process, Number of copies being made, Number of approvals required, Amount of time required to process a request, Number of errors requiring re-work and Level of user satisfaction.

Analyze:

Using information gotten in the measure phase, xerox pinpoints bottlenecks, causes of variations and identifies non value added activities and the improvement areas. Cost effectiveness of the project is determined by considering hard cost and benefits to be gained. Technological recommendations are then provided. A **Value Steam Map** is an important tool in this phase to check existing process and uncover inefficiencies. Its made up of customer value added task, business value added task and non value added tasks.

Improve:

Xerox implements recommended solutions. Project plan is developed and actions taken. A pilot program is started which later leads to the full scale deployment if successful. Key to this stage are end users acceptance and company wide change without affecting current performance levels. Common imaging and repository solutions implemented in the Improve

phase include scanning services, Web-based document access, and workflow solutions for task tracking and automation.

Control:

Xerox places necessary controls to maintain improvements in the long term. Involves monitoring key process metrics to promote continuous improvement and prevent regression. Xerox revisits implementation after 3-6months to review key metrics and evaluate if program is sustained. This is done by observing hard cost savings and achievement of pre defined service level.

CASE SUMMARY 8

Lean Six Sigma and Environment Case Study: JEA

JEA is an electric, water and sewer utility company in Jacksonville, Florida. It has been applying lean six sigma process in its activities since 2000. This paper describes lean and six sigma at JEA.

Lean and six sigma at JEA

JEA selected six sigma methodology in 1999, began training black belts in 2000 and conducted its 1st six sigma project in 2001. It integrated lean and six sigma in 2007

JEA uses the DMAIC protocol of six sigma.

In 2008, JEA added a sixth step (Green it up) to the DMAIC making it DMAGIC. This was to ensure that every improvement project addresses environmental concerns using environmental metrics. After identifying the root causes, JEA measures air quality, water quality and ecosystem related issues. Changes needed are integrated before making countermeasures. See environmental matrix below used to identify root causes of environmental issues identified.

	Project X's → *Root Causes*	Outcome 2	Outcome 3	Outcome 4	Outcome 5
	Air Quality Issues				
1	Climate Change				
2	Air Emissions				
3	Odor Impacts				
	Water Quality Issues				
4	Groundwater and Aquifer Quality				
5	Surface Water Quality incl. St. Johns River				
6	WWTP/WRF Discharge				
7	Sanitary Sewer Overflows				
8	Reclaimed Water				
	Waste Stream Issues				
9	Solid Waste By-Products				
10	Hazardous Waste Management				
11	Chemical or Oil Spills				
12	Waste Reduction and/or Recycling				
	General Ecosystem Issues				
13	Wetlands Impacts				
14	Tree and Vegetation Impacts				
15	Wildlife Impacts				
	Societal and Economic Issues				
16	Environmental Stakeholder Relationships				
17	Environmental Regulatory Agency Interface				
18	Power Reliability/Quality				
19	Drinking Water Quality				
20	Energy Conservation				
21	Water Conservation				

ST Johns River Nitrogen Discharge Reduction Project

Define: Problem statement: Nitrogen Discharge flunctuation

After studying 67 weeks of data, it was observed that nitrogen discharge was at its lowest always on Friday evening and rose each weekend to reach its peak on Monday morning

declining subsequently through out the week; negatively affecting monthly nitrogen totals reported to the EPA.

Measure, Analyze and Green it up

Applying the DMAGIC process, team identified and analyzed root causes of high nitrogen discharge levels on Mondays. Using brainstorming, testing and implementation process changes were made to address the root causes and plan of action to reduce nitrogen levels without negatively affecting plant operations.

Possible causes of high nitrogen included

- Airflow, primary effluent biological oxygen demand(BOD), disolved oxygen, food to microorganism ratio and water temperature.

Process improvement team performed a **multivariate regression analysis** to determine the relevance of potential causes of variation on nitrogen discharge. They concluded that the fish processing facility nearby ceased work on weekends and caused the sewage treating microbes to die off between Friday and Monday thereby spiking nitrogen levels.

JEA developed the hypothesis that the microbes could be fed over the weekends with byproducts of the process of making biodiesel which was part of a six sigma project conducted in 2007 in Jacksonville.

Improve and control

1. Team reclassified waste products from the creation of biodiesel, considered a hazardous material as a product of Nitro-gene.

2. JEA feeds Nitro-gene to the microbes during the weekends, reducng nitrogen discharge to the river.

3. introduction of high temperature side streaming process. Super microbes able to withstand 106 degrees Fahrenheit environment of the sidestream were created as part of an improvement program resulting in greater ability to rescue nitrogen output.

Benefits

1. Nitrogen discharge reduction by 74 tons per year.
2. Meet Federal standards on time without additional cost in treatment technology, decreased operational cost.
3. Potential savings of $2.37 million per yearfrom nitrogen credits.
4. Increased cooperation between JEA and local municipalities.
5. Biodiesel recycling
6. Customer satisfaction, improved public perception of JEA.